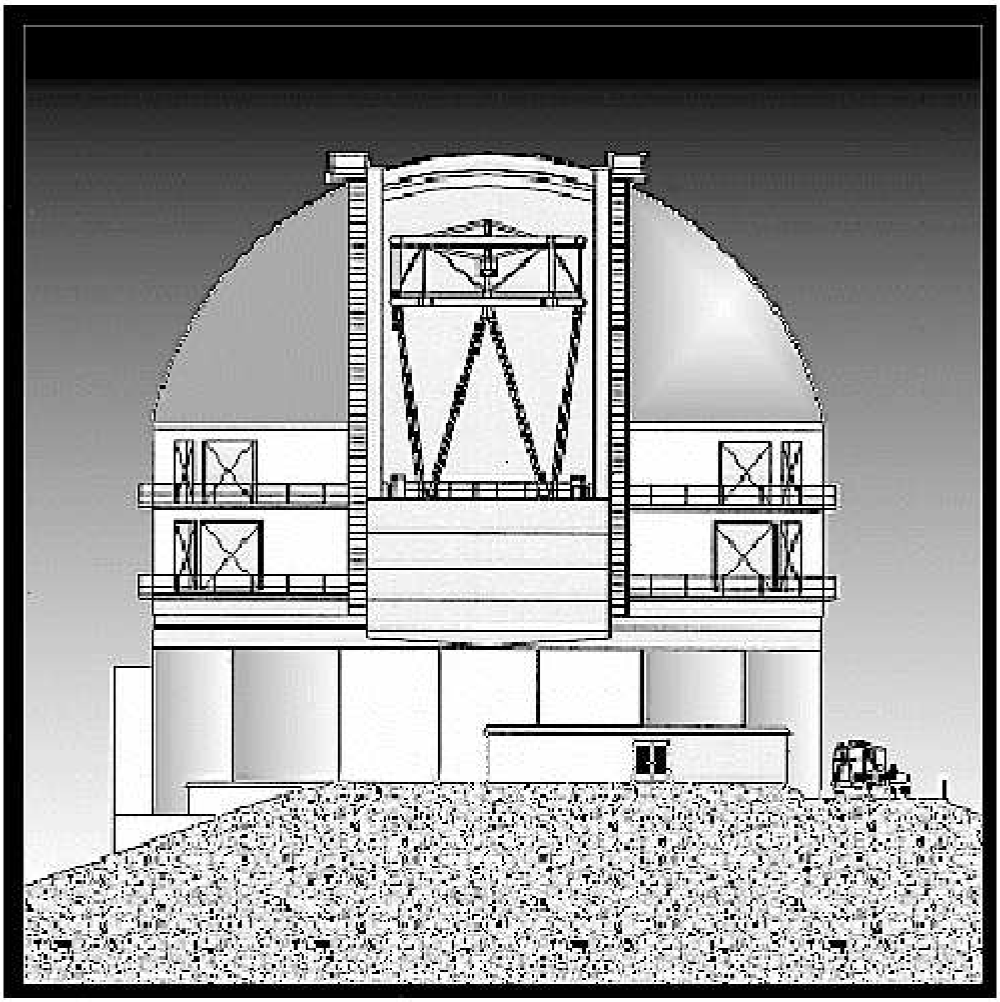
GEMINI
8-M Telescopes Project

RPT-PS-G0065

The Gemini Instrumentation Program



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INTRODUCTION

The Gemini instrumentation program consists of two distinct components; a Phase I program and a Phase II program. The Phase I program is supported largely from contruction funding, approved by the Gemini Board and currently underway. The Phase II program, supported totally from operations funding, is yet to be defined. The Phase I instrumentation capabilities will permit a rapid scientific exploitation of the Gemini facilities while the Phase II instrument development program will serve to enhance and upgrade the initial instrumentation and provide next-generation instruments. The following is a thumbnail sketch of the elements of the Phase I program, and a Strawman listing of possibilities for the Phase II program. Initial funding for the Phase II program is expected to start in 1997, and our intent is to prepare a baseline Phase II program for Gemini Science Committee (GSC) and Gemini Board consideration in the fall of 1996.

The guiding principles of the Gemini instrumentation program are:

1) Instruments must be science driven and reflect the scientific aspirations of the Gemini partnership
2) Preference should be given to instruments that exploit the unique characteristics of the Gemini telescopes
3) The instrumentation program should ensure that the partnership has access to superior or complementary capabilities when compared to other telescopes
4) Because of the high level of intellectural return inherent to designing and building scientific instruments, instruments will be allocated to the partner countries approximately in proportion to their contributions.

Comments on the scientific priorities for Phase II instrumentation program elements and/or new scientific capabilities that Gemini should consider for Phase II are encouraged.

I. Phase I Program elements

All of the effort going into the telescope and facility design naturally leads to tight performance specifications for the facility instrumentation. Table 1 lists the scientific instruments that will make up the initial complement at each site.

The Phase I program includes a Natural Guide Star (NGS) Adaptive Optics System (AOS), being built in Canada for the Mauna Kea telescope. The AOS is designed for use in the 0.9 to 2.5µm range and is expected to deliver Strehl Ratios of at least 0.5 at 1.6µm under median seeing conditions to the cassegrain instrumentation ports while preserving the f/number and focal plane location.

Table 1: Initial Scientific Instrumentation

Mauna Kea	Cerro Pachon
◆ Multi-Object Spectrograph (GMOS-N)	◆ Multi-Object Spectrograph (GMOS-S)
◆ Near IR Imager (NIRI)	◆ High Resolution Optical Spectrograph (HROS)
◆ Near IR Spectrograph (NIRS)	
◆ NGS Adaptive Optics (AOS)	
←Mid IR Imager (MIRI) (shared N/S)→	
◆ Shared Instrumentation with UKIRT	◆ Shared Instrumentation with CTIO
↳ Mid-IR Spectrograph (MICHELLE)	↳ Near IR Spectrograph
	↳ Near IR High-Resolution Spectrograph (NIRS-S)
	↳ Commissioning IR Imager (COB)

NIRI

The 1-5µm imager is being built by UH, will be used for commissioning the Mauna Kea telescope, as well as scientific observations. It will utilize a 1024^2 InSb array, have plate scales of 0.02, 0.05 and 0.11"/pixel (for use with and without AO), and very low internal instrument background, consistent with the low telescope emissivity. NIRI is designed with a pupil imaging mode, space for 20-30 cold filters, and accomodation for a R~700 grism for the 1-2.5µm range, and a wollaston prism together with a range of options for masking at the cold field and pupil stops. The optics are sized to accomodate an upgrade to 2048x2048 arrays for the two finer pixel scales.

NIRS

The 1-5µm spectrograph for Mauna Kea is being built by NOAO, and is also based on use of a 1024^2 InSb array. It will provide spectral resolutions of 2000 and 6000 for two plate scales (0.05"/pixel and 0.15"/pixel), cross dispersion and polarizing prism capability. Space in front of the cold slit is available for a future integral field module. The NIRS Conceptual Design Review was held 22 March 1996.

Both 1-5µm instruments are equipped with internal sensors operating in the 1-2.5µm range, which provide tip/tilt and fast focus error signals from reference stars in a 3.5 arcmin dia field of view, fed by either dichroics or near field pick off mirrors.

GMOS

There will be two Gemini Multi-Object spectrographs (GMOS), operating over the 0.36 to 1.1µm range, one for Mauna Kea, with coatings optimized for red performance, and one for Cerro Pachon, with coatings optimized for blue preformance. Each incorporates three 2kx4k CCD arrays, an image scale of 0.08"/pixel, spectral resolution of up to 10,000 and an integral field module with 0.2" spatial sampling. Upgrade options include extending the wavelength coverage to 1.8µm and additional integral field modules. The GMOS's also include an imaging mode, primarily to support definition of the multi- slit masks. On-instrument sensing of tip/tilt and focus error is achieved with a pickoff mirror feeding a 2x2 Shack-Hartmann mask with a CCD. The GMOS are a collaboration between Canada and the UK. A Preliminary Design Review (PDR) was held 26, 27 March 1996.

MIRI

The 8-30μm imager will initially be deployed at Mauna Kea and will be available for use at first light on Cerro Pachon. The GSC requirements for this instrument specify that it utilize at ~256x256 Si:As IBC array, a pixel scale of < 0.13"/pixel, and an internal instrument background consistent with the low telescope emissivity. This instrument includes capacity for 20-30 cold filters and desirable upgrade options for utilization of 512x512 arrays and a near IR on-instrument tip/tilt and focus sensor. A Request for Proposal (RFP) for the conceptual design of MIRI is expected to be issued by the US Gemini Program Office in April 1996.

HROS

The GSC requirements for the High Resolution Optical Spectrograph (HROS) specify that it will have resolutions of around 50,000 and 120,000 at a slit witdth of 0.6" and 0.24" respectively. The highest priority is throughput, particularly in the UV. A conceptual design study for HROS is currently underway in the UK.

COB

The commissioning instrument for the Cerro Pachon telescope will be a 1-5μm imager borrowed from CTIO. This instrument is expected to be the Cryogenic Optical Bench (COB) currently in use on the KPNO telescopes. NOAO plans to upgrade COB to include a 512x512 to 1024x1024 InSb array and make it available at CTIO in 1996. On Gemini, COB will have a 0.05" pixel size, a internal dichroic feed for guiding, a pupil imaging mode, 2 filter wheels, a grism spectroscopy capability (R~ 500) and a polarimetry option.

II. Operations Budget Instrumentation Support

A. Phase I Instrumentation Program Completion

The bulk of the funding for the HROS, and the Mid-IR imager is from the Operations plan. These two instruments are essential elements of the Phase I plan prepared by the GSC and approved by the Gemini Board. Completion of some of the other basic instruments may require the use of some Operations plan funding. These capabilities currently include the 0.2 arcsec IFU for GMOS-N and GMOS-S and completion of the filter set for the NIRI.

B. Shared Instrumentation

Because of the limited budget available for the Phase I instrumentation, The GSC has encouraged Gemini to explore agreements with NOAO and PPARC for the use and support of shared instruments. The shared instrumentation currently under consideration are:

MICHELLE

MICHELLE is a mid-IR spectrometer under development at ROE for use at UKIRT with proposed shared use on Gemini-North. It will provide a wide range of spectral resolution, from 200 to 30,000, and diffraction limited imaging capability in the 8 - 28μm range.

PHOENIX

PHOENIX is a near-IR high resolution spectrometer, providing spectral resolution up to 100,000 in the 1-5 um range. It will see first use on NOAO telescopes in 1996. The shared use of PHOENIX between CTIO telescopes and Gemini-south is under consideration.

NIRS

NOAO is considering cloning the NIRS for use as a shared instrument between CTIO and Gemini-South. The NIRS is a basic "workhorse" instrumental capability with wide ranging unique scientific capability on Gemini-South.

C. Phase I Instrument upgrades

The following Phase I instrument upgrade options are considered to be cost effective for the early Phase II Instrumentation Program, and a high-priority upgrade.

GMOS Upgrades

Upgrade GMOS-N with addition of a near-IR camera to the Gemini-North GMOS using 1kx1k or 2kx2k HgCdTe arrays to provide high performance multi-object spectroscopy in the 1-1.8μm region.

NIRS Upgrades

The NIRS is designed to accomodate multiple gratings, and substantial space for an Integral field unit. The integral field unit will provide for near diffraction limited spatial sampled spectroscopic observations ranging from distant galaxies to forming stars. The NIRS is equipped with a grating turret which can accomodate an additional grating. Addition of a higher dispersion grating can expand the spectral resolution coverage to around 40,000.

HROS Upgrades

Upgrade to use in the high stability lab within the telescope pier, probably via a fibre feed. Provides very stable environment for precision radial velocity measurements.

D. Additional upgrades to Phase I instruments and New Instrument Capabilities

The following capabilities are illustrative of types of instrumentation options and new capabilities that would significantly enhance the scientific capabilities of the gemini telescopes.

AOS (Gemini-South)

The Gemini-South facility will be a superb facility for Adaptive Optics observations. A laser beacon system, together with a near-IR tip/tilt and focus sensor, will provide a unique capability to extend and complement Northern hemisphere obsevations.

AOS (Gemini-North)

A Laser Guide Star upgrade to the NGS AOS would boost adaptive optics (AO) sky coverage to nearly 100%. When combined with a Near-IR sensor for tip/tilt correction this system would enable high performance AO imaging/spectroscopic observations in dark clouds - one of Gemini's key science drivers.

GMOS (Gemini-North and Gemini-south)

Addition of a high order on-instrument WFS for AO would eliminate throughput losses associated with facility AOWFS dichroic. A high resolution Integral Field Unit would provide very high spatial resolution spectroscopy when used with AO.

Wide Field Optical Imager

Boost baseline science visible imaging capability beyond the imaging mode of GMOS, with larger field of view, finer image scale and higher throughput. This instrument could potentially be shared between Gemini-North and -South as the science applications dictate.

IR Coronagraph

A dedicated, optimized design to support coronagraphic imaging. Gemini will be a unique platform for coronagraphic observations because of the exceptionally smooth primary mirror, rigorous mirror cleaning program, and apodizing options within the AOS.

NIRI

Upgrade the Near-IR imager to a 2kx2k InSb array format. The imager is designed to accomodate a 2kx2k detector format for the two finer plate scales. This upgrade will be particularly useful for the AO mode which currently provides only 20" square field of view, much smaller than the isoplanitic patch size at near-IR wavelengths

NIRI (Gemini-South)

Duplication of Upgraded NIRI. 1-5μm imaging will be a "workhorse" capability for Gemini, exploiting the superb image quality and extremely low emissivity. COB has a small OIWFS field of view, a single plate scale, and other properties that limit its range of scientific observation capability.

MIRI

Upgrade to 512x512 array format. The imager is designed to accomodate a 512x512 detector. The isoplanitic patch size for diffraction limited imaging at 10 and 20μm is much larger than the field of view of the MIRI.

Polarization capability

Polarization measurements require implementation of the polarizaion analyzer upgrade in the A&G unit as well as providing the wollastan prism upgrades in the NIRI and NIRS. Both instruments are designed to accomodate these prisms. The combination of precision polarization measurement and high spatial resolution observations using the NIRI and the IFU capability in the NIRS will be extremely powerful tool for the study of AGN phenomenon.